U.S. Department of Energy Commercial Reference Buildings - Benefits and Applications

Welcome to the Webinar! We will start at 12:00 Noon Eastern Standard Time

Be sure that you are also dialed into the telephone conference call:

Dial-in number: (888) 843-6171; Pass code: 1658993

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There will be a Q&A session at the end. Questions will be submitted electronically and answered verbally. Submit your questions by selecting "Q&A" on the menu at the top, click in the top box, type your question and click "Ask."

Today's Speakers

Jim Rannels leads the Commercial Buildings Integration and Deployment Team at the U.S. Department of Energy Building Technologies Program. His team works to improve the efficiency of commercial buildings through fostering industry alliances and partnerships, researching building technologies and strategies, and developing energy simulation software.

Michael Deru, Ph.D., is a Senior Engineer II for the Center for Buildings and Thermal Systems at the National Renewable Energy Laboratory (NREL). Dr. Deru leads the DOE Commercial Building Benchmark Project at NREL, which is developing standard energy models of commercial buildings for DOE research. He uses EnergyPlus and NREL optimization programs to develop energy design guides for several commercial building types, and has been the project manager for the U.S. Life Cycle Inventory Database since its inception.

Kristin Field is a Mechanical Engineer at NREL, with several years of building energy simulation experience, primarily using EnergyPlus software. Ms. Field performed a significant portion of the energy modeling for the DOE commercial reference buildings. She also leads a modeling effort to determine radiant cooling savings in India office buildings, and is the fFacilitator and Technical Lead of the Restaurant and Food Preparation Subcommittee of the DOE's Retailer Energy Alliance.

Bing Liu, P.E., is a Senior Research Engineer at Pacific Northwest National Laboratory (PNNL) with more than 15 years of experience in sustainable building design and analysis, energy efficiency analysis and simulation, and high-performance building metering and measurement. Ms. Liu leads the PNNL commercial building simulation team supporting the next generation of codes and standards (ASHRAE Standard 90.1 and IECC). She is also chairing the project committee to develop the first Advanced Energy Design Guide book targeting 50% energy savings for small to medium offices.

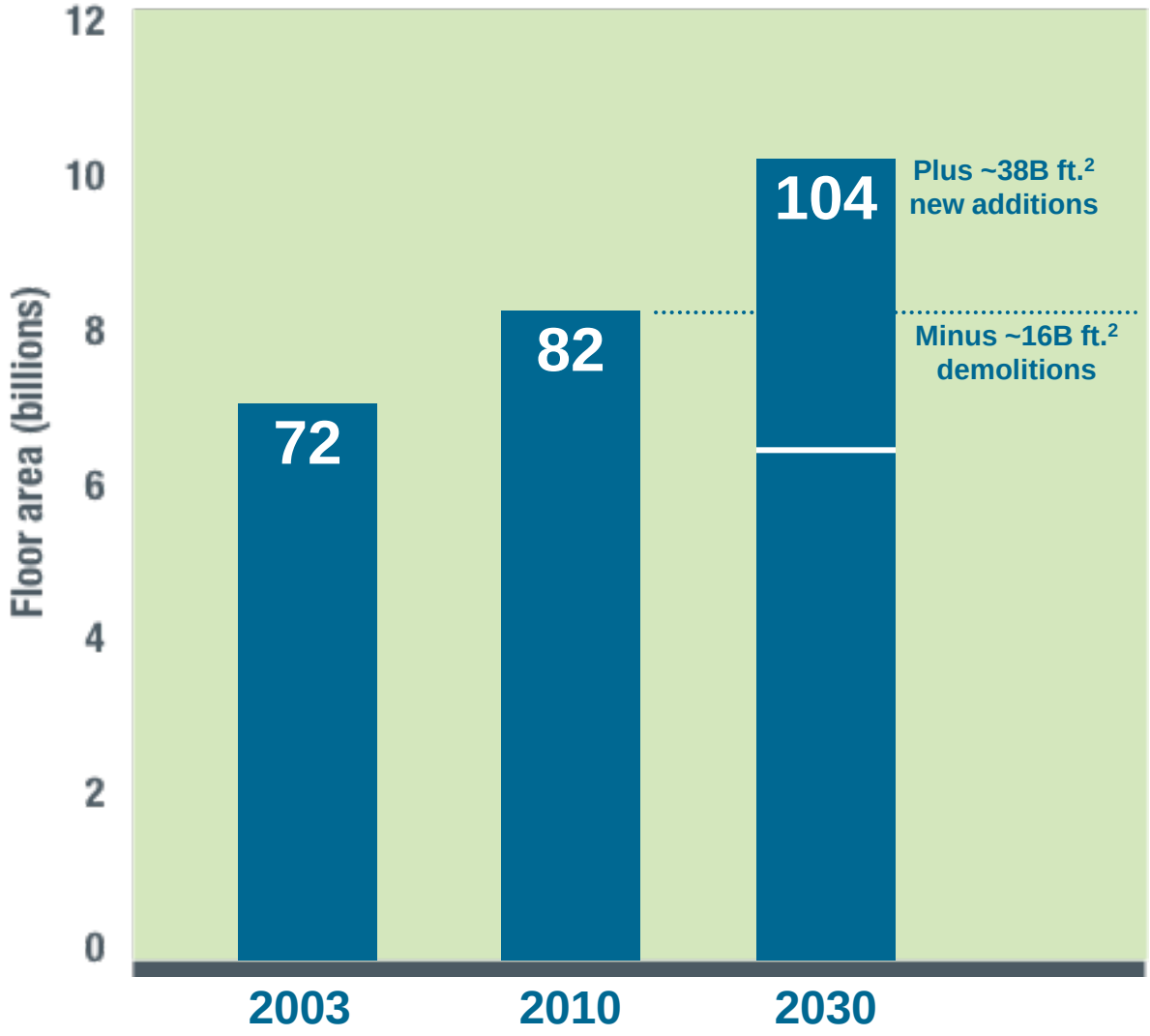
Reference Buildings & Models: Concept & Structure

James Rannels
U.S. Department of Energy
Energy Efficiency and Renewable Energy
May 18, 2010

Commercial Buildings' Energy Share

- Commercial buildings account for:
  - 18% of U.S. energy
  - 18% of greenhouse gas emissions (~1,000 MMT of CO_2e)
  - slightly less than India's entire energy consumption and GHG emissions

Commercial Square Footage Projections



Source: EIA's *Annual Energy Outlook 2009*, Table 5.

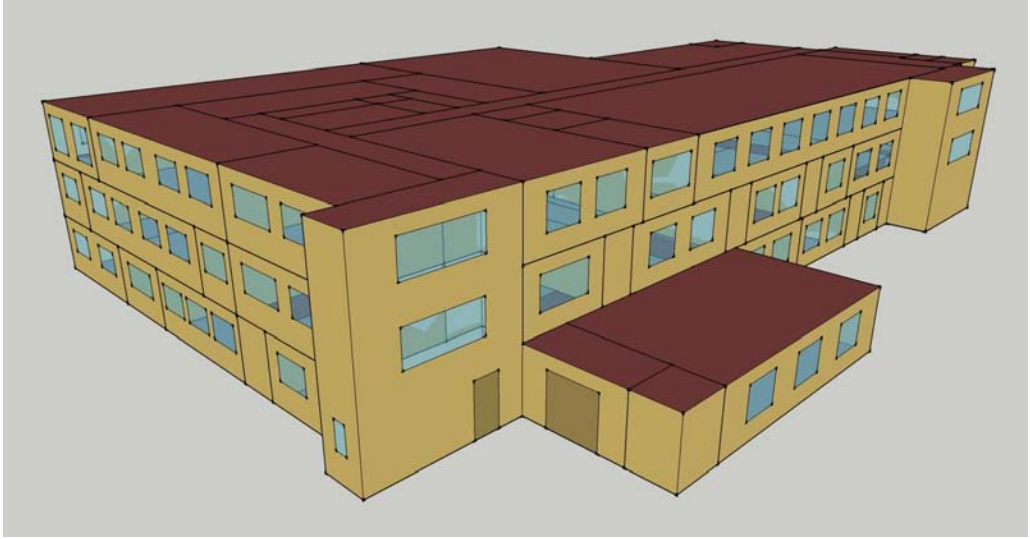
Simulation in Low-Energy Building Research

- In DOE's low-energy building research, simulation has been critical for designing and operating buildings to support decision-making

- But we need 'reference' models to represent new and existing buildings for research and technology evaluation.

Reference Buildings

- NREL, PNNL, and LBNL developed reference buildings
  - Set of standardized buildings that can be used as a code-compliant starting point
  - Can be used for sector analysis (building stock weights)
  - Can be used to set performance targets by specific climate or other parameters (covers all climate zones)
  - Can be used to show progress toward goals



National Renewable Energy Laboratory
Innovation for Our Energy Future

DOE Commercial Reference Building Development and Application

Michael Deru, PhD – NREL
Kristin Field – NREL

Dru Crawley – DOE (former)
Brent Griffith, Kyle Benne, and Danny Studer – NREL
Bing Liu, Mark Halverson, Dave Winiarski, and Michael Rosenberg – PNNL
Joe Huang and Mehry Yazdanian – LBNL

May 18, 2010

Motivation

- Developing good energy models is a lot of work! – 1,000's of inputs
- Often depend on default values and inputs from other simulations

➔Standard reference models provide a common set of inputs that people can "trust"

Approach

- Balance of accuracy and practicality
  - Best estimations when there is limited data
- Review and buy in by the modeling community
  - DOE and other researchers
  - ASHRAE review
- Data sources
  - CBECS and construction start data
  - ASHRAE standards
  - AEDG committees
  - Existing research

Commercial Reference Buildings

- 16 building types
- 16 locations
- Three sets of buildings (more in the future)
  - New construction – 90.1-2004
  - Post-1980 construction (~90.1-1989)
  - Pre-1980 construction (pre energy standards)
- 16 x 16 x 3 = 768 models!

Reference Building Models (16)

	Building Activity	Area ft^2	Floors	Source
Office	Small Office	5,500	1	Small Office AEDG
	Medium Office	53,630	3	2003 CBECS
	Large Office	498,588	12	2003 CBECS
School	Primary School	73,960	1	K-12 AEDG
	Secondary School	210,890	2	K-12 AEDG
Retail	Stand-alone Retail	24,962	1	2003 CBECS
	Strip Mall	22,500	1	2003 CBECS
	Supermarket	45,000	1	2003 CBECS
Food service	Quick Service Restaurant	2,500	1	2003 CBECS
	Full Service Restaurant	5,500	1	2003 CBECS
Lodging	Small Hotel	43,200	4	Highway Lodging AEDG
	Large Hotel	122,120	6	2003 CBECS
Health care	Hospital	241,351	5	2003 CBECS
	Outpatient health care	40,946	3	Health Care AEDG
Storage	Warehouse	52,045	1	Warehouse AEDG
Resi-dential	Midrise Apartment	33,740	4	PNNL

Reference Building Locations

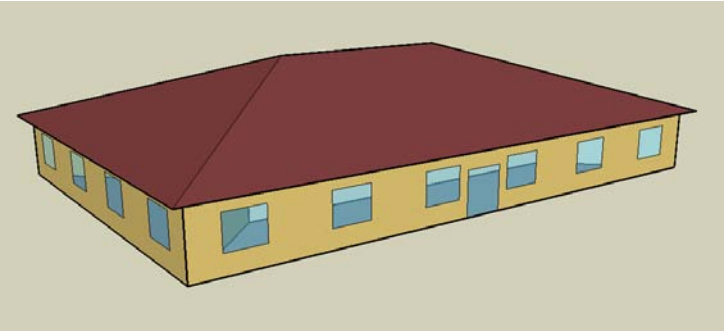
No	Climate Zone	Reference Bldg. City	DOE City
1	1A	Miami FL	Miami FL
2	2A	Houston TX	Houston TX
3	2B	Phoenix AZ	Phoenix AZ
4	3A	Atlanta GA	Memphis TN
5	3B-CA	Los Angeles CA	
6	3B-other	Las Vegas NV	El Paso TX
7	3C	San Francisco CA	San Francisco CA
8	4A	Baltimore MD	Baltimore MD
9	4B	Albuquerque NM	Albuquerque NM
10	4C	Seattle WA	Salem OR
11	5A	Chicago IL	Chicago IL
12	5B	Denver CO	Boise ID
13	6A	Minneapolis MN	Burlington VT
14	6B	Helena MT	Helena MT
15	7	Duluth MN	Duluth MN
16	8	Fairbanks AK	Fairbanks AK

Weighting Factors

- Each weighting factor represents the number of buildings represented by each Reference Building in each location
- Allows results from each Reference Building to be projected across sectors and regions
- Developed from construction start data from 2003-2007 ➔ For new (recent) construction

	1A	2A	3A	3B	3C	4A	4B	4C	5A	5B	6A	6B	7	8
Small Office	201.9	2559.5	695.7	2316.1	1142.2	187.0	2251.0	113.9	294.8	2213.0	774.1	580.2	72.7	77.8
Medium Office	31.9	200.5	72.0	188.9	176.4	33.5	293.5	9.0	48.3	261.4	84.4	73.6	8.6	8.1
Large Office	2.7	8.6	1.6	11.8	7.6	3.1	30.0	0.0	4.1	11.7	3.2	3.5	0.0	0.3
Pri. School	11.4	167.0	29.4	169.0	79.8	8.5	160.1	5.4	16.8	164.6	40.0	30.1	6.7	4.2
Sec. School	10.1	95.5	14.4	118.8	51.4	6.9	126.3	4.0	15.2	143.2	27.5	26.1	5.4	4.7

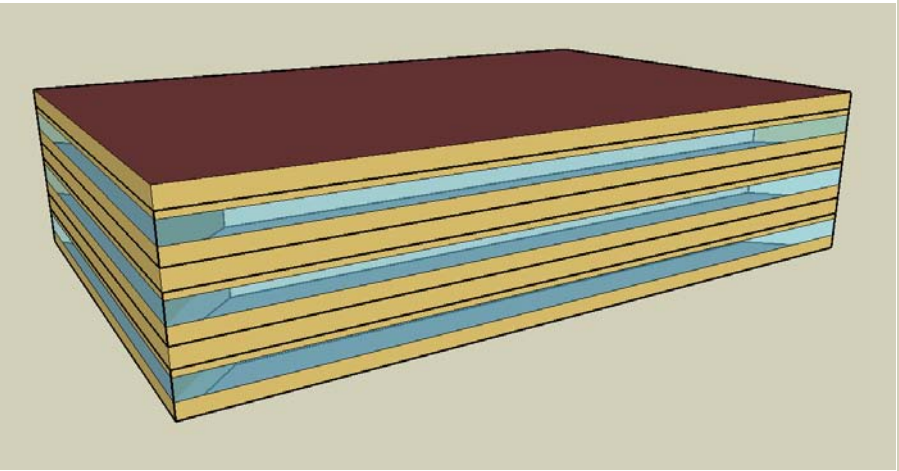
Office Buildings

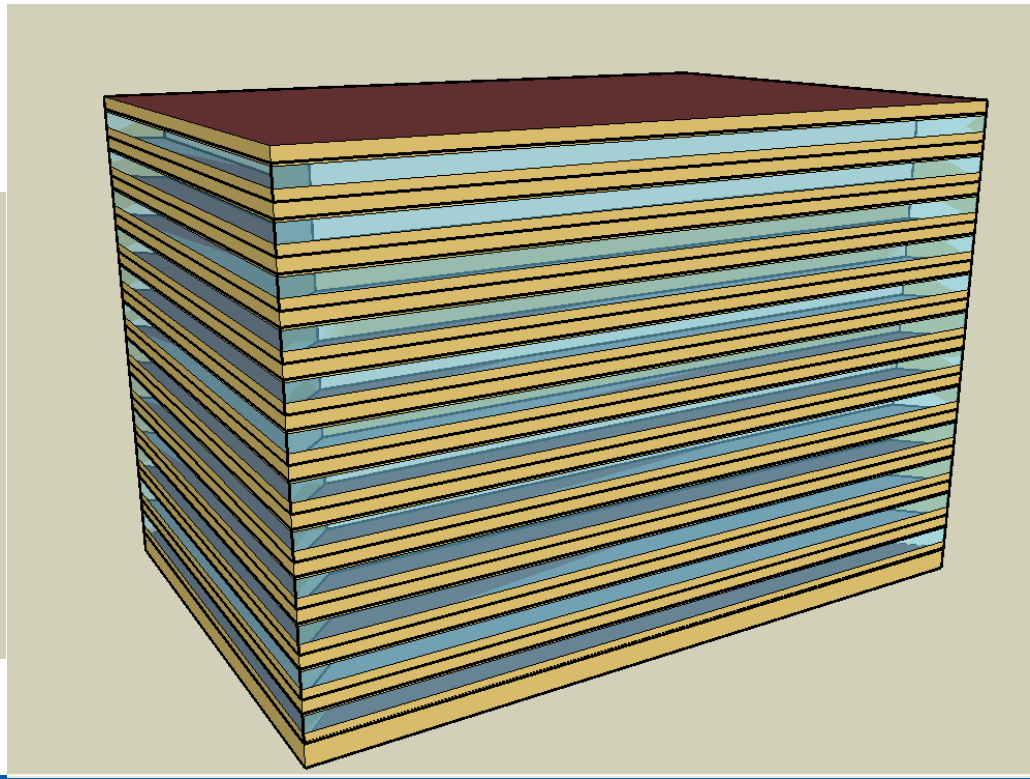


Small Office
1 floor, 5,500 ft^2

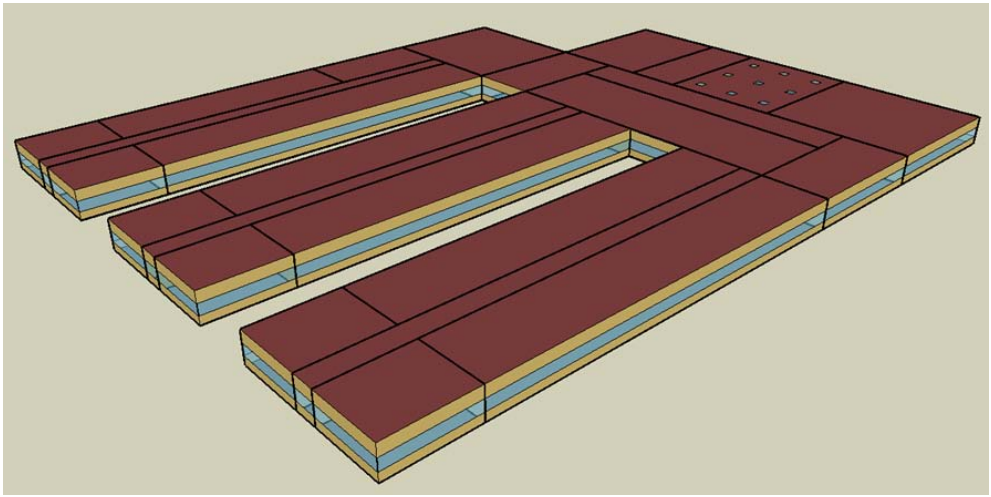
Large Office
12 floors, 498,588 ft^2

Medium Office
3 floor, 53,630 ft^2

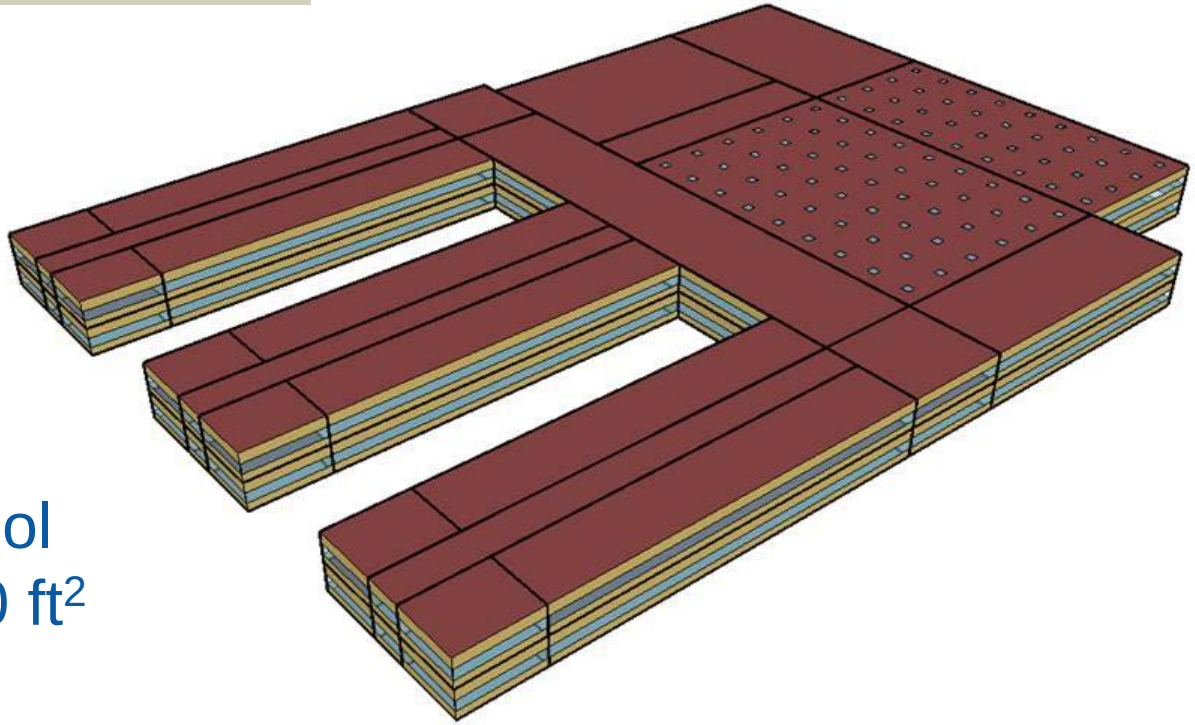




Schools

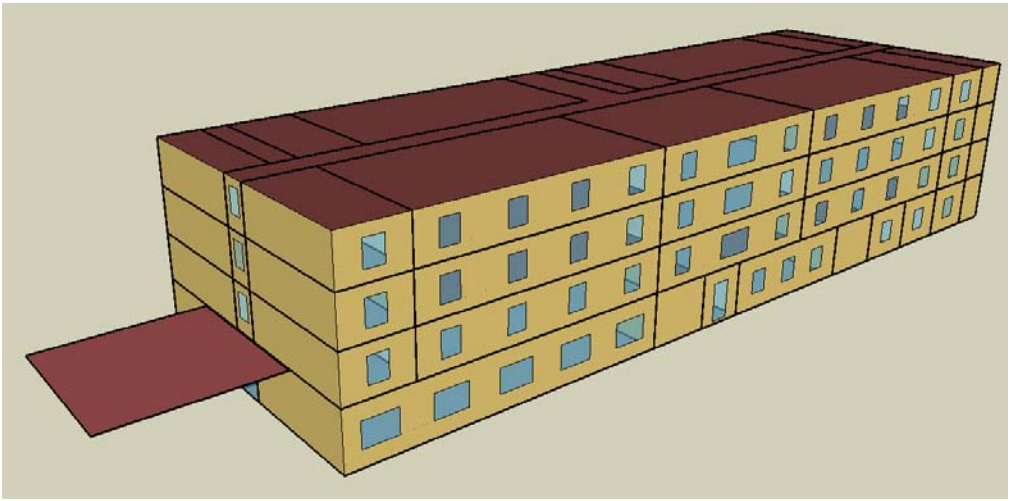


Primary School
1 floor, 73,960 ft^2

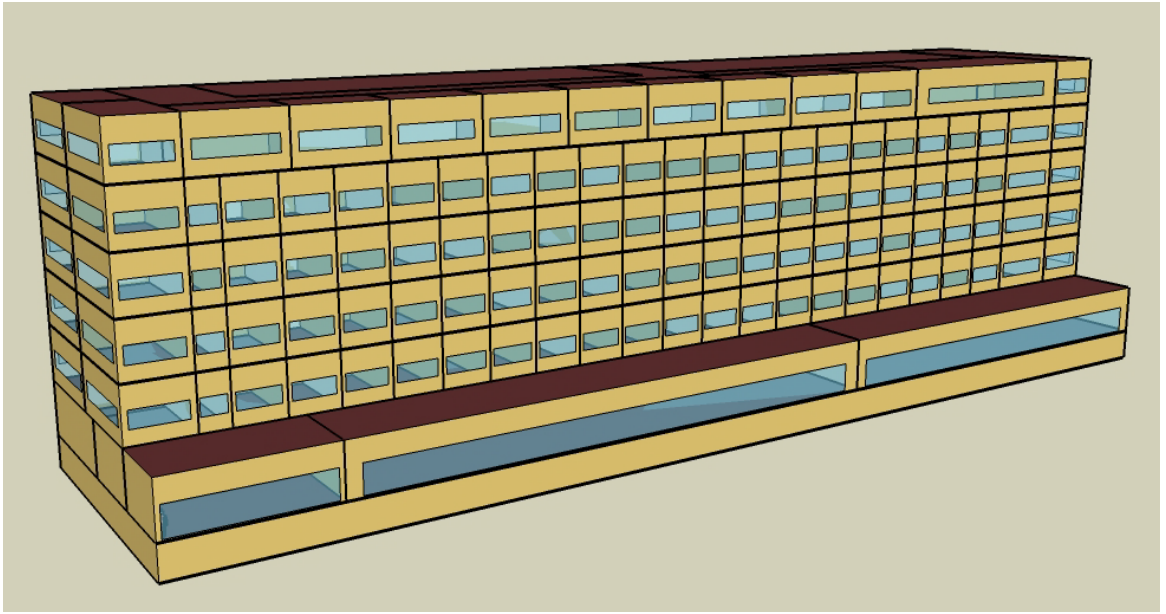


Secondary School
2 floors, 210,890 ft^2

Lodging

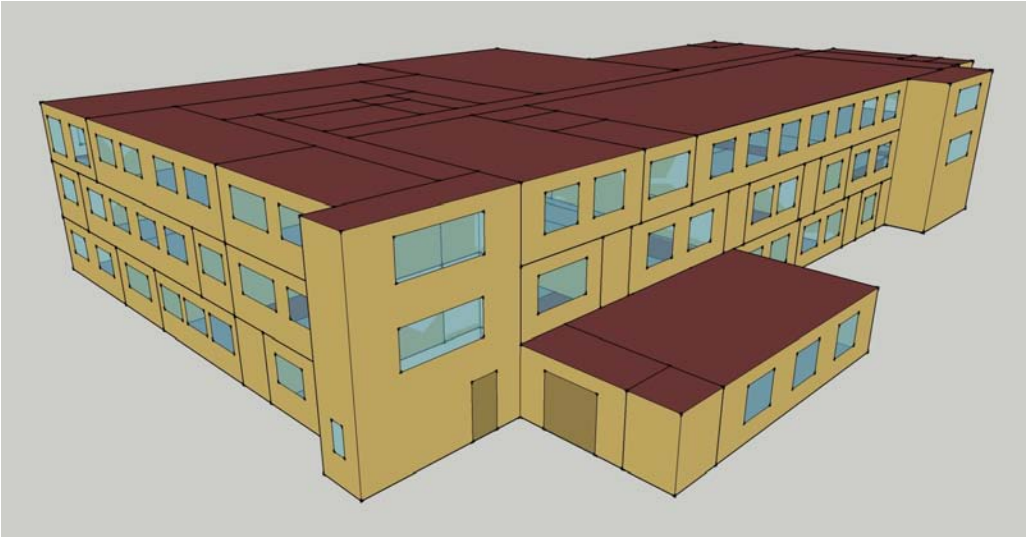


Small hotel
4 floors, 43,200 ft^2

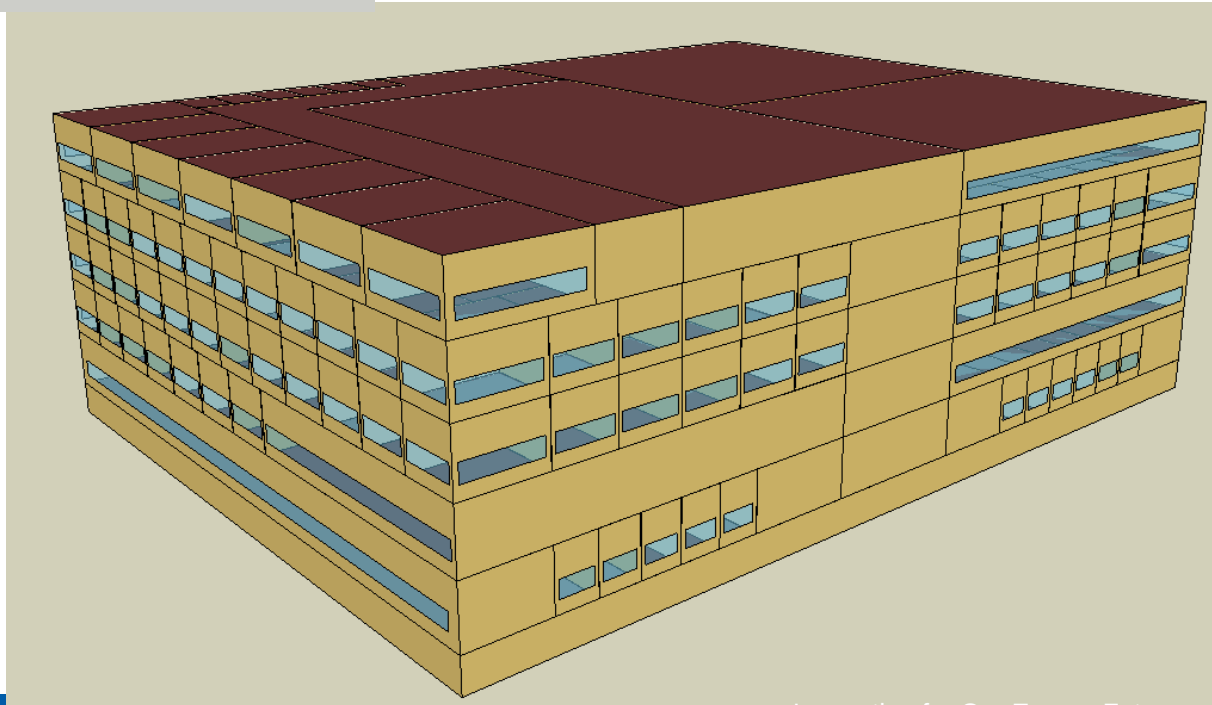


Large hotel
6 floors, 122,120 ft^2

Healthcare



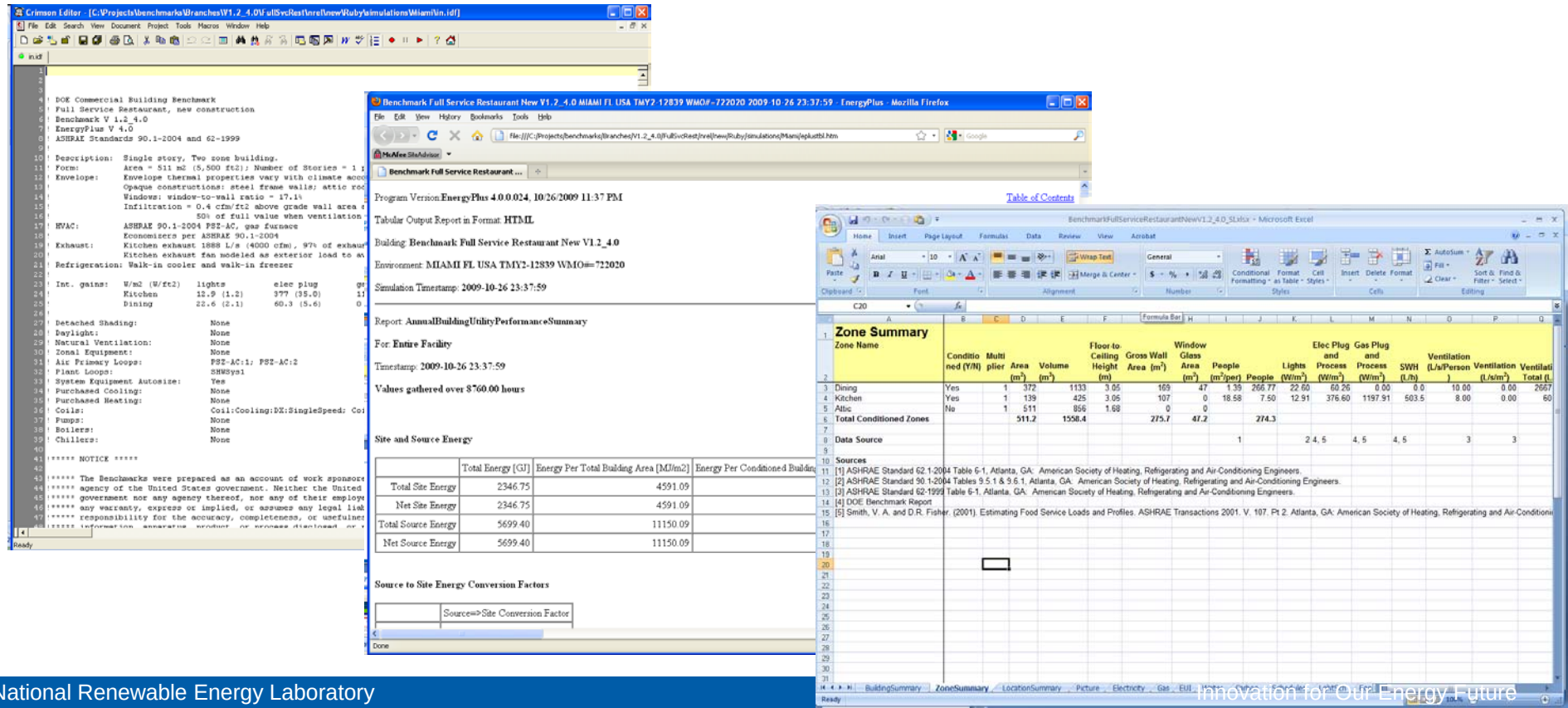
Outpatient Healthcare
3 floors, 40,946 ft^2



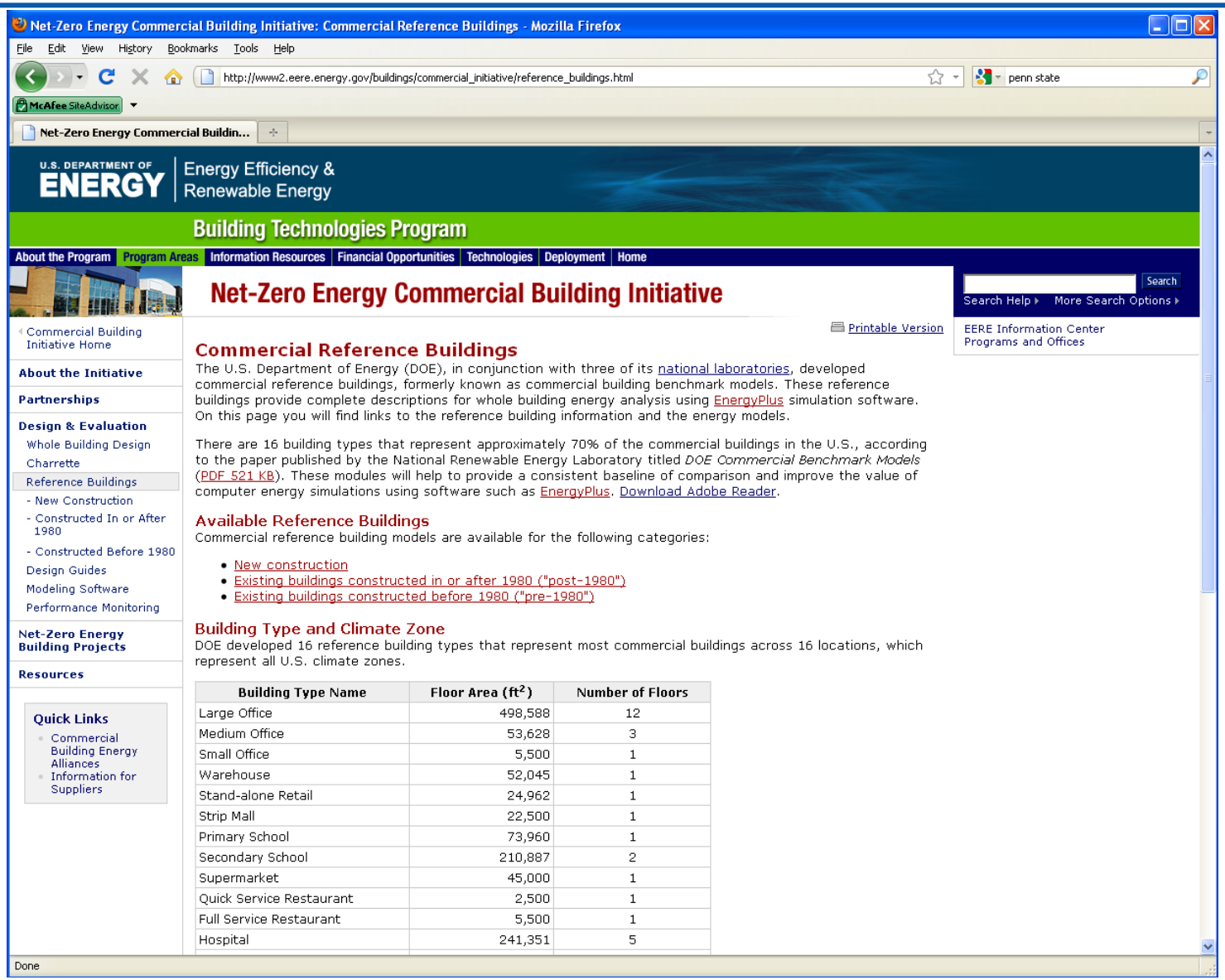
Hospital
5 floors, 241,351 ft^2

What's Available?

- EnergyPlus input and html output files
- Scorecards – spreadsheets with input parameters and output results
- Project report (coming summer 2010)



Where Can You Get Them?



http://www1.eere.energy.gov/buildings/commercial_initiative/reference_buildings.html

How Should They Be Used?

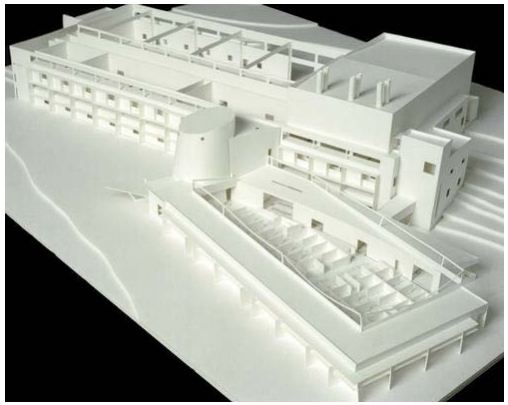
- Common, reference-able starting points
- Fully functional, vetted EnergyPlus example files
- Storage of a body of buildings knowledge
- Study of one building type in many climates
  - Relative consumption/demand by climate
  - Differing effects of energy design measures by climate
- Study of several building types in one climate
  - Estimate (rough) aggregate community load profile
  - Develop a list of energy design measures appropriate to a specific region

How Should They Not Be Used?

- Prediction of utility bills (as with any energy model)
- Proxy for a specific proposed building
- To study building types that differ significantly from the 16 reference buildings
  - Examples:
    - Significant modifications to warehouse model need to be made if modeling a refrigerated warehouse
    - Large lab buildings would have greater diversity than the lab space types in reference buildings
    - Large theater, stadium not represented
    - Recreation center/gym/pool not represented
    - And others, use good judgment!

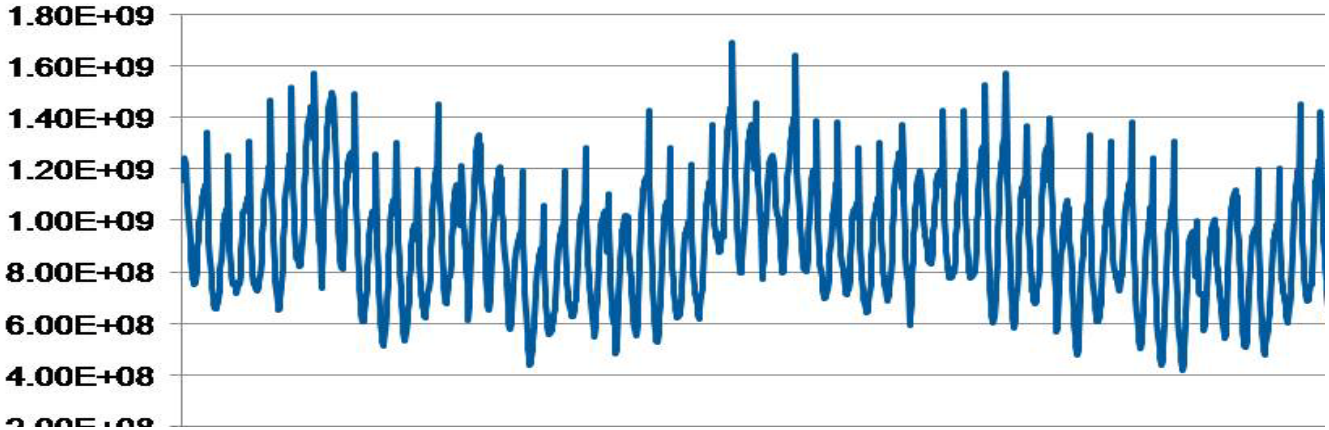
Example Applications

- Ice Storage Modeling
- Comparison of Rooftop Units
- Estimating Effects of Building Vintage
- ASHRAE Standards Evaluation



Ice Storage Modeling

- Private sector company specializing in ice storage technology
- Ice storage system performance depends on building load profile
- Reference buildings used to generate prototypical hourly load profiles
- Hourly load profiles → In-house performance calculator



Comparison of Rooftop Units

- Research institute study
- Test effects of high-efficiency natural gas furnace sections on rooftop units
  - Different building types
  - Different climates
- Answers the question: when is it worth the extra capital cost?
- Institute needed models already complete so that it could focus on equipment performance

Effects of Building Vintage

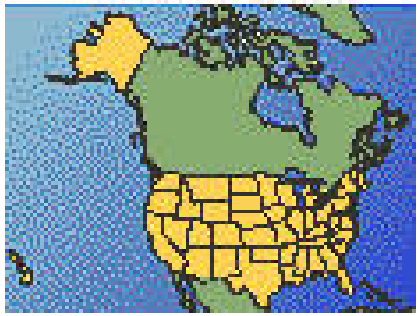
- Purpose: help characterize all building stock for studies, not just new construction
- Comparison of 3 building “vintages”
  - New construction 90.1-2004
  - Constructed in 1980s or 1990s
  - Constructed before 1980
- Major changes to energy models
  - Lighting power densities (LPDs)
  - Cooling equipment COPs
  - Heating equipment efficiencies
  - Infiltration
  - Some changes in system types
  - Envelope

Effects of Building Vintage

- LPDs and infiltration were most influential changes overall
- Vintage comparisons:
  - New to Post-1980 ← much bigger!
  - Post-1980 to Pre-1980
- Wide range of increased energy use intensities (EUIs)
  - Building types with high process loads showed smaller % increases new to existing
    - Restaurants
    - Health care
- Remember: results are not prediction of increase in utility bills over time

Evaluation of ASHRAE Standards

- Standard 100
  - Existing buildings efficiency standard
  - Primarily uses CBECS 2003 for baseline comparison values
  - Problem: Not all building types in all U.S. locations are represented significantly in CBECS dataset
  - Solution: Use reference building models to "stretch" the dataset
    - Example
      - Determine baseline value for retail building in City A
      - City A has little or no retail buildings in CBECS
      - No reliable baseline value for City A
      - City B does have good retail representation
      - Use stand-alone retail reference building
      - Simulate in both City A and City B
      - Determine ratio of consumption A/B
      - Baseline A = (Ratio A/B) * (CBECS value for City B)



Evaluation of ASHRAE Standards

- Standard 189.1
  - Reference models with some variations
    - ASHRAE 90.1-2004, Appendix G system types
    - Other minor variations
  - Goal: 30% reduction over ASHRAE 90.1-2007
  - Weighted average result: 29.7% savings
    - First iterations fell short
    - Reference models allowed standard committee to gauge progress toward 30% goal
  - 20% savings from energy efficiency measures
  - 10% savings from required renewables

- Standard 90.1 

DOE Building Technologies Program

May 18, 2010
Webinar

U.S. Department of Energy
Energy Efficiency and Renewable Energy

Using the Reference Building Models for the Standard 90.1-2010 Development

Bing Liu, P.E., C.E.M. LEED AP

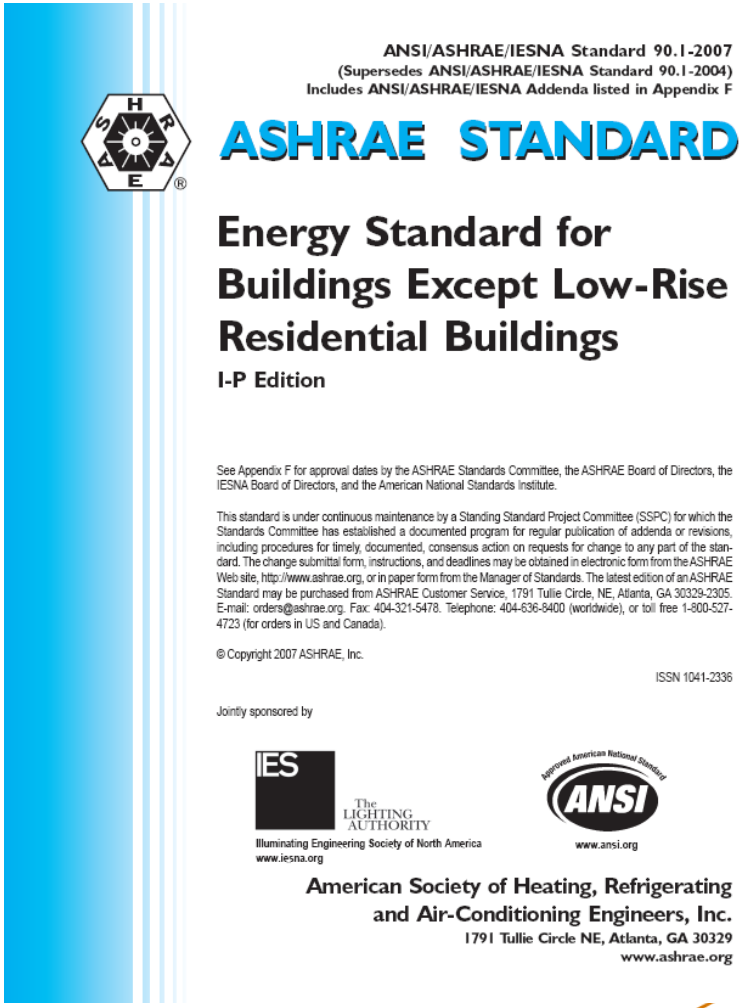
Senior Research Engineer

Pacific Northwest National Laboratory

Pacific Northwest
NATIONAL LABORATORY

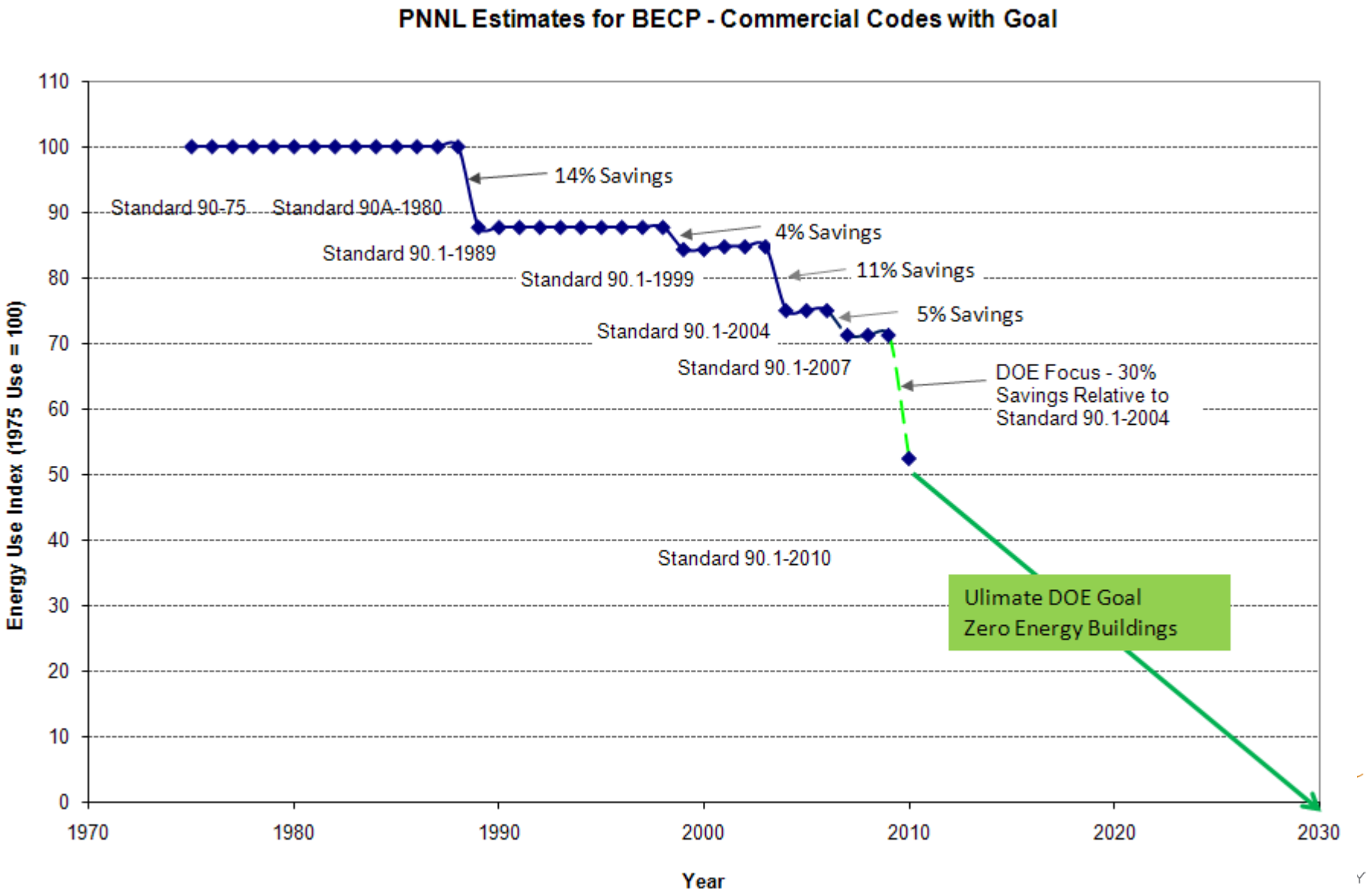
ASHRAE Standard 90.1

- Energy design standard for commercial and multi-family residential buildings (>3 stories)
- Baseline of many above-code programs for commercial building energy efficiency, including AEDGs, Standard 189.1, and LEED
- Developed in an ANSI consensus process by ASHRAE and IES in a 3-year publication cycle



Pacific Northwest
NATIONAL LABORATORY

History of ASHRAE Standard 90.1



PNNL's Building Simulation Support to ASHRAE Standard 90.1

- DOE's Determination
  - Estimate the energy savings of 90.1-2007 and 90.1-2010 as part of DOE's Quantitative Analysis.
- Energy Saving Analyses
  - Support subcommittees' new proposals
  - Develop the building load profile spreadsheet tools for mechanical subcommittee
- Progress Indicator
  - Measure progress toward the 30% improvement goal in Standard 90.1-2010

Progress Indicator - Overview

- Measure progress toward the 30% improvement goal in Standard 90.1-2010
  - Baseline is 90.1-2004
  - Standard 90.1-2007
  - Standard 90.1-2010 (the approved addenda to 90.1-2007)
  - Update Progress Indicator (PI) and report to ASHRAE 90.1 committee at each quarterly meeting

- Calculate the national weighted-average energy savings
  - Assign the new construction weights to each prototype by climate zone
  - National weighted-average EUI and energy cost for each prototype
  - National weighted energy and cost saving percentage across various building types

- PNNL's EnergyPlus Simulation Frame Structure
  - Each set of PI will need run 1632 EnergyPlus models

    1632 runs = 16 prototypes x 17 locations x 3 Standards x 2 Ventilation Stand[illegible]
  - Automatic process to read into the modeling inputs and extract the modeling results

90.1 Simulation - Prototype Buildings

McGraw-Hill New Construction Data by Building Type

Serial No	ASHRAE Prototype	Total Floor Area (x1000 ft²)	Construction Weights
1	Large Office	220,134	2.66%
2	Medium Office	400,091	4.84%
3	Small Office	371,009	4.49%
4	Stand-alone Retail	1,009,246	12.21%
5	Strip Mall	375,093	4.54%
6	Primary School	330,418	4.00%
7	Secondary School	685,508	8.29%
8	Hospital	228,131	2.76%
9	Outpatient Health Care	289,171	3.50%
10	Full-service Restaurant	43,650	0.53%
11	Quick -service Restaurant	38,809	0.47%
12	Large Hotel	327,562	3.96%
13	Small hotel/motel	113,837	1.38%
14	Non-refrigerated warehouse	1,105,951	13.38%
15	High-rise apartment	593,241	7.18%
16	Mid-rise apartment	484,343	5.86%
	Covered by Prototypes	**6,616,193**	**80.0%**
17	No Prototype	1,649,785	20.0%
18	Total	8,265,977	100.0%

Download PNNL report on construction weights:

http://www.pnl.gov/main/publications/external/technical_reports/PNNL-19116.pdf

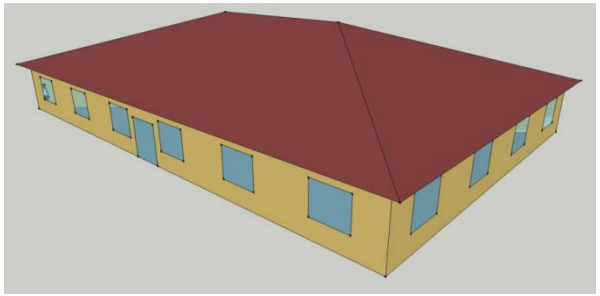
	CBECS Type	Total Floor Area (x1000 ft²)	Weights
17A	Pubic Assembly	414,953	5.02%
17B	Food Sales	96,990	1.17%
17C	Other	769,423	9.31%
17D	Public Order and Safety	121,907	1.47%
17E	Religious Worship	184,143	2.23%
17F	Service	62,369	0.75%

90.1 Simulation – New Construction Weights

	1	2A	2B	3A	3B	3C	4A	4B	4C	5A	5B	6A	6B	7	8	weights by bldg type
Large office	0.102	0.326	0.061	0.445	0.285	0.117	1.132	0.000	0.154	0.442	0.121	0.133	0.000	0.011	0.000	**3.33**
Medium office	0.129	0.813	0.292	0.766	0.715	0.136	1.190	0.036	0.196	1.060	0.342	0.298	0.035	0.033	0.007	**6.05**
Small office	0.084	1.064	0.289	0.963	0.475	0.078	0.936	0.047	0.123	0.920	0.322	0.241	0.030	0.032	0.005	**5.61**
Standalone retail	0.224	2.220	0.507	2.386	1.250	0.191	2.545	0.119	0.428	3.429	0.792	0.948	0.091	0.109	0.014	**15.25**
Strip mall retail	0.137	0.991	0.254	1.021	0.626	0.103	1.008	0.023	0.107	1.023	0.201	0.153	0.016	0.007	0.001	**5.67**
Primary school	0.064	0.933	0.164	0.944	0.446	0.048	0.895	0.030	0.094	0.920	0.224	0.168	0.037	0.023	0.003	**4.99**
Secondary school	0.160	1.523	0.230	1.893	0.819	0.109	2.013	0.063	0.243	2.282	0.438	0.415	0.086	0.075	0.012	**10.36**
Hospital	0.040	0.479	0.096	0.468	0.273	0.039	0.615	0.022	0.106	0.812	0.218	0.221	0.024	0.034	0.001	**3.45**
Outpatient health care	0.037	0.567	0.134	0.581	0.275	0.061	0.818	0.023	0.181	1.058	0.218	0.342	0.033	0.039	0.002	**4.37**
Full-service restaurant	0.009	0.106	0.025	0.111	0.047	0.006	0.127	0.006	0.010	0.143	0.031	0.031	0.004	0.004	0.000	**0.66**
Quick-service restaurant	0.008	0.092	0.020	0.102	0.063	0.007	0.089	0.005	0.014	0.128	0.026	0.025	0.003	0.004	0.000	**0.59**
Large hotel	0.109	0.621	0.125	0.635	0.793	0.106	0.958	0.037	0.123	0.919	0.200	0.227	0.058	0.038	0.004	**4.95**
Small hotel	0.010	0.288	0.030	0.268	0.114	0.022	0.315	0.020	0.039	0.365	0.089	0.107	0.031	0.020	0.004	**1.72**
Warehouse	0.349	2.590	0.580	2.966	2.298	0.154	2.446	0.068	0.435	3.580	0.688	0.466	0.049	0.043	0.002	**16.72**
High-rise apartment	1.521	1.512	0.076	0.652	0.741	0.173	2.506	0.000	0.358	1.163	0.115	0.125	0.016	0.008	0.000	**8.97**
Mid-rise apartment	0.257	1.094	0.093	0.825	0.862	0.260	1.694	0.022	0.371	1.122	0.318	0.313	0.056	0.032	0.000	**7.32**
weights by zone	**3.24**	**15.22**	**2.98**	**15.03**	**10.08**	**1.61**	**19.29**	**0.52**	**2.98**	**19.37**	**4.34**	**4.21**	**0.57**	**0.51**	**0.06**	**100.00**

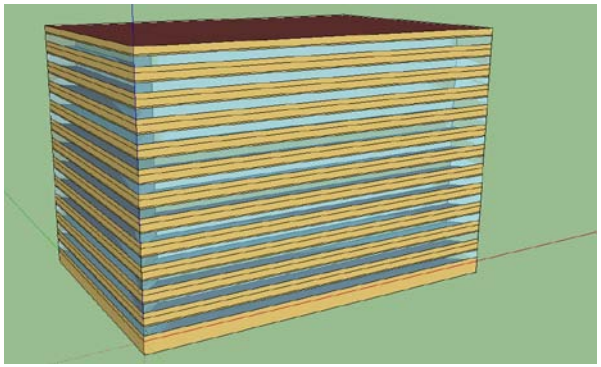
3 Office Prototypes

Small Office



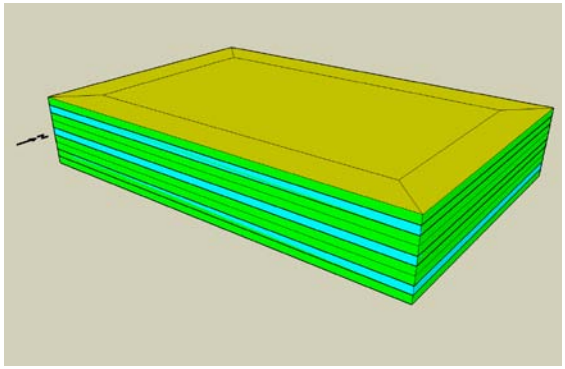
Floor area (ft²)	Number of Floors	Aspect Ratio	WWR
5,500	1	1.5	15%

Large Office



Floor area (ft²)	Number of Floors	Aspect Ratio	WWR
498,600	12 (plus basement)	1.5	40%

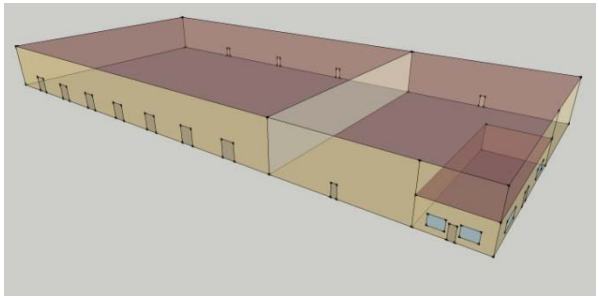
Medium Office



Floor area (ft²)	Number of Floors	Aspect Ratio	WWR
53,600	3	1.5	33%

1 Warehouse Prototype

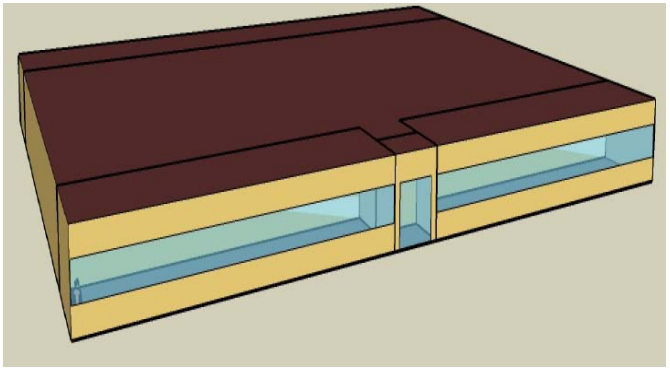
Non-refrigerated warehouse



Floor area (ft²)	Number of Floors	Aspect Ratio	WWR
49,500	1	2.2	Office area: 12% Storage Area: 0% Overall: 0.71%

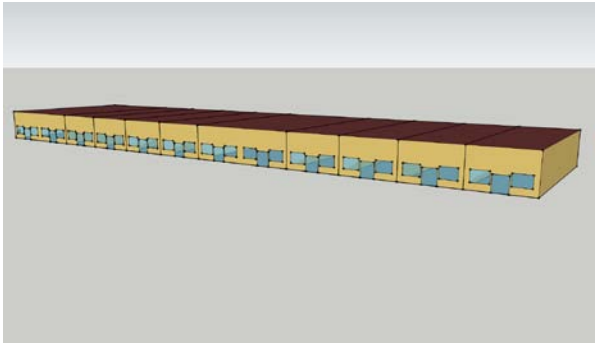
2 Mercantile Prototypes

Stand-alone Retail



Floor area (ft²)	Number of Floors	Aspect Ratio	WWR
24,695	1	1.28	7%

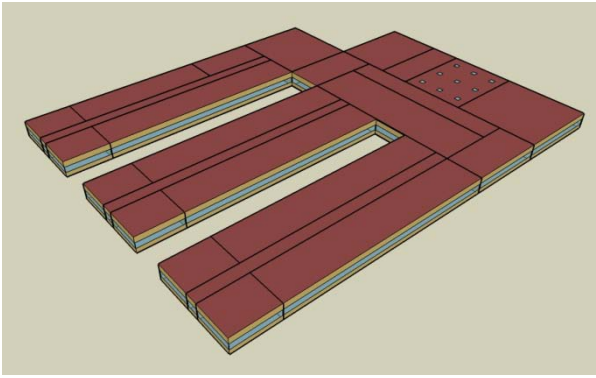
Strip Mall



Floor area (ft²)	Number of Floors	Aspect Ratio	WWR
22,500	1	4	11%

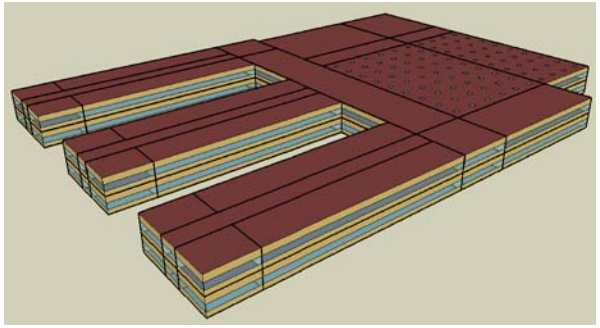
2 Education Prototypes

Primary School



Floor area (ft²)	Number of Floors	Aspect Ratio	WWR
74,000	1	NA	35%

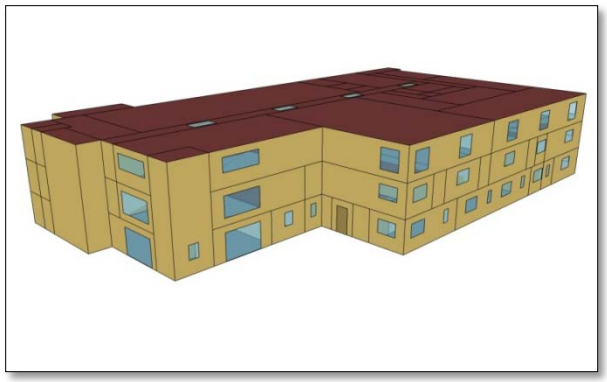
Secondary School



Floor area (ft²)	Number of Floors	Aspect Ratio	WWR
210,900	2	NA	33%

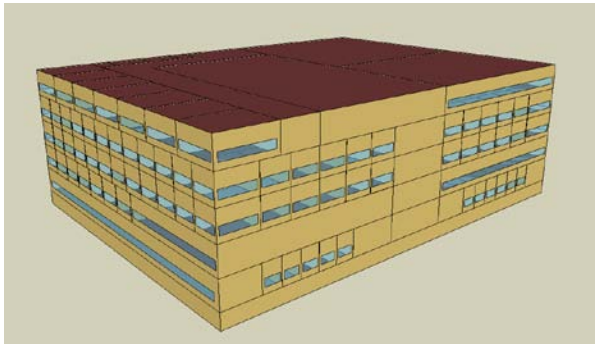
2 Health Care Prototypes

Outpatient Health Care



Floor area (ft²)	Number of Floors	Aspect Ratio	WWR
40,950	3	NA	20%

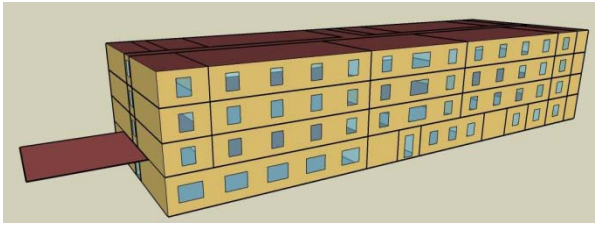
Hospital



Floor area (ft²)	Number of Floors	Aspect Ratio	WWR
241,410	5 (plus basement)	1.33	16%

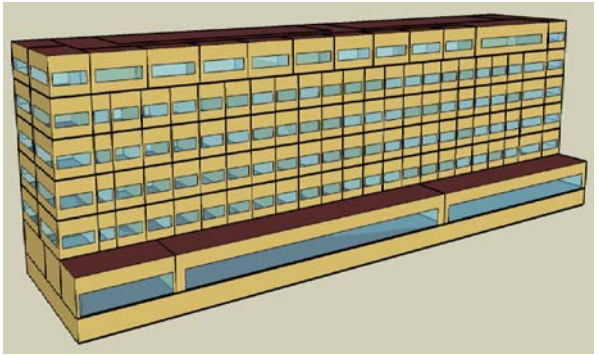
2 Lodging Prototypes

Small Hotel



Floor area (ft²)	Number of Floors	Aspect Ratio	WWR
43,200	4	3	11%

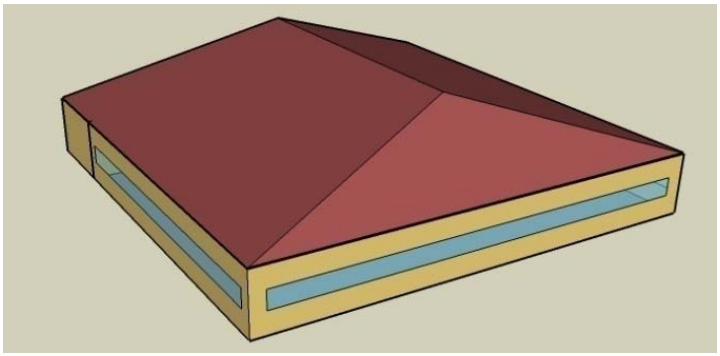
Large Hotel



Floor area (ft²)	Number of Floors	Aspect Ratio	WWR
122,132	6 (plus basement)	Ground & basement floor: 3.8 All other floors: 5.1	27%

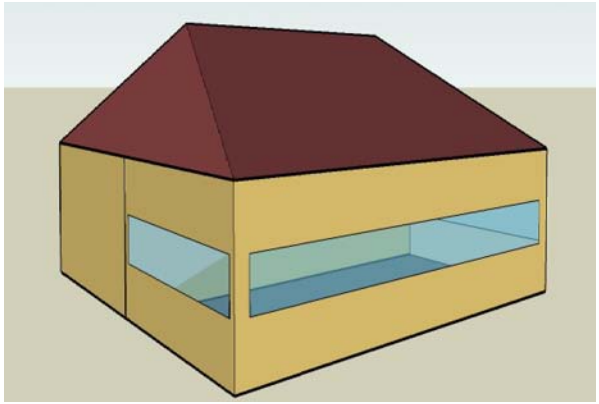
2 Food Service Prototypes

Full-Service Restaurant



Floor area (ft²)	Number of Floors	Aspect Ratio	WWR
5,500	1	1	18%

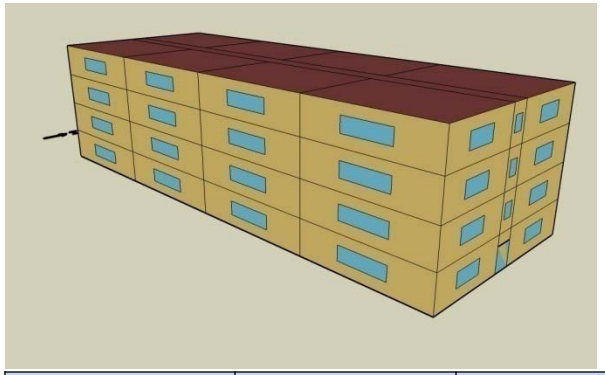
Quick-Service Restaurant



Floor area (ft²)	Number of Floors	Aspect Ratio	WWR
2,500	1	1	14%

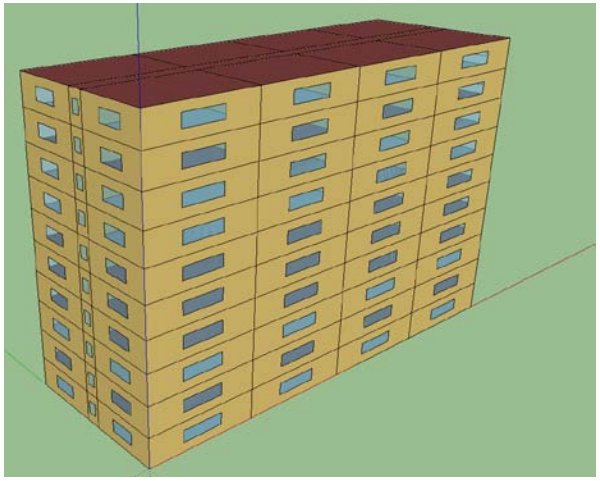
2 Apartment Prototypes

Mid-rise Apartment



Floor area (ft²)	Number of Floors	Aspect Ratio	WWR
33,700	4	2.74	15%

High-rise Apartment



Floor area (ft²)	No. of Floors	Aspect Ratio	WWR
84,360	10	2.75	15%

Progress Indicator - Addenda

- 90.1-2007
  - 44 addenda to 2004
- 90.1-2010
  - 61 approved addenda to 2007 through April 2010
- Total 105 addenda compared to 90.1-2004
  - 86 addenda in Section 5 through 10

Descriptions	No. of Addenda
Addenda in section 5 through 10 (prescriptive sections)	86
Addenda with no energy saving impacts	36
Addenda with energy savings	50
Savings that can be captured in Progress Indictor	38
Savings that cannot be captured in Progress Indictor	12

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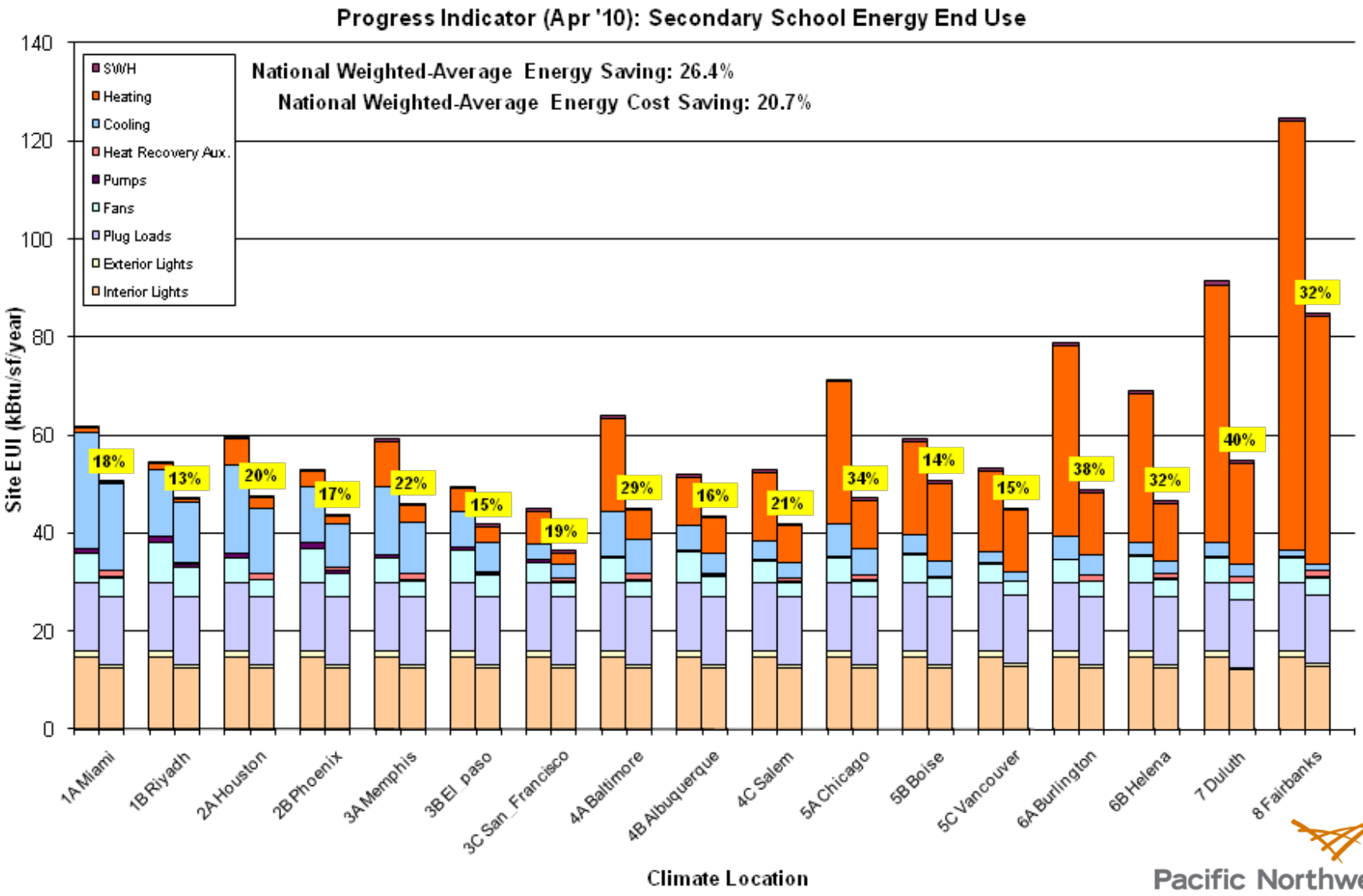
April 2010 Progress Indicator Summary

Building Prototype	Site Energy [kBtu/sf]		Energy Cost [$/sf]		Site Energy Savings	Energy Cost Savings
	90.1-2004	Apr2010 PI	90.1-2004	Apr2010 PI		
Small office	40.0	35.4	$1.04	$0.92	11.3%	11.5%
Medium office	46.7	40.7	$1.22	$1.03	12.8%	15.2%
Large office	40.6	35.8	$1.03	$0.93	11.8%	10.0%
Standalone retail	71.9	51.9	$1.70	$1.26	27.8%	26.1%
Strip mall	75.9	62.9	$1.78	$1.45	17.1%	18.5%
Primary school	70.9	56.8	$1.62	$1.36	19.9%	16.1%
Secondary school	62.8	46.2	$1.45	$1.15	26.4%	20.7%
Outpatient healthcare	151.3	134.0	$3.58	$3.16	11.4%	11.8%
Hospital	154.4	145.5	$3.39	$3.18	5.8%	6.2%
Small hotel	69.2	64.8	$1.53	$1.43	6.4%	6.7%
Large hotel	153.0	142.8	$2.93	$2.77	6.7%	5.6%
Warehouse	27.4	22.5	$0.56	$0.46	17.9%	16.6%
Quick-service restaurant	532.7	509.9	$10.17	$9.74	4.3%	4.2%
Full-service restaurant	377.1	357.2	$7.49	$6.95	5.3%	7.2%
Mid-rise apartment	43.5	39.7	$1.04	$0.95	8.7%	8.5%
High-rise apartment	44.0	41.3	$1.11	$1.05	6.2%	5.8%
National-weighted average	**69.8**	**59.5**	**$1.58**	**$1.36**	**14.7%**	**14.0%**

Progress Indicator Summary

Building Type	Building Prototype	October 2009	January 2010	April 2010
Office	Small office	10.4%	11.3%	11.3%
	Medium office	11.6%	13.0%	12.8%
	Large office	9.5%	11.7%	11.8%
Retail	Stand-alone retail	15.9%	18.2%	27.8%
	Strip mall	9.4%	17.2%	17.1%
Education	Primary school	11.7%	13.0%	19.9%
	Secondary school	10.1%	14.0%	26.4%
Health Care	Outpatient healthcare	11.0%	11.8%	11.4%
	Hospital	NA	5.8%	5.8%
Lodging	Small hotel	5.9%	6.1%	6.4%
	Large hotel	3.1%	6.7%	6.7%
Warehouse	Warehouse	14.9%	14.0%	17.9%
Food Service	Quick-service restaurant	0.5%	4.3%	4.3%
	Full-service restaurant	2.6%	4.9%	5.3%
Apartment	Mid-rise apartment	8.7%	8.7%	8.7%
	High-rise apartment	NA	4.6%	6.2%
National-weighted Average		**9.8%**	**11.4%**	**14.7%**

Example: Secondary School



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Next Steps - June 2010 Progress Indicator

- Apply additional BOD-approved addenda to June 2010 PI
  - Addendum AS (VAV turndown for medical zones)
    - Checking the energy saving results in hospital
    - Will work on the outpatient as well
  - Addendum CB (automatic OA damper requirements for buildings < 3 stories)
    - Need to change the OA dampers for some of baseline models as well
  - Addendum M (chiller performance)
    - Received the chiller performance curves from 90.1 committee
    - Currently conducting sensitivity analysis
  - Addendum S (DX performance)
    - Waiting for the DX performance curves
  - and more…
- Apply addenda with potentially big energy impacts to forecast the 90.1-2010 results
  - Addendum BB (envelope)
  - Addendum BY (lighting power density)
  - Addendum CY (economizer)

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Time for Questions…

PNNL's Commercial Simulation Team

Bing Liu

- Mike Rosenberg
- Dr. Weimin Wang
- Dr. Yulong Xie
- Brian Thornton
- Yunzhi Huang
- Dr. Heejin Cho
- Dr. Jian Zhang
- Rahul Athalye
- Vrushali Mendon

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Thank you for attending the Webinar

U.S. Department of Energy Commercial Reference Buildings - Benefits and Applications

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